

## CLAIMS

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### WHAT IS CLAIMED IS:

1. A 3-D adaptive laser powder fusion welding system for subjecting a workpiece to  
2 laser powder fusion welding, the system comprising:  
a laser head system;  
4 a linear displacement element coupled to the laser head and enabling the laser  
head to be displaced linearly in a first dimension; and  
6 a support apparatus capable of holding the workpiece adjacent the laser head  
in an adjustable and selectable manner, the support apparatus providing five degrees  
8 of freedom in second and third linear dimensions and first, second, and third  
rotational dimensions; whereby  
10 the laser head may engage the workpiece about an exterior of the workpiece.
2. A 3-D adaptive laser powder fusion welding system for subjecting a workpiece to  
2 laser powder fusion welding as set forth in Claim 1, wherein the laser head system further  
comprises:  
4 a laser welding head.
3. A 3-D adaptive laser powder fusion welding system for subjecting a workpiece to  
2 laser powder fusion welding as set forth in Claim 1, wherein the laser head system further  
comprises:  
4 a powder feed delivery system.
4. A 3-D adaptive laser powder fusion welding system for subjecting a workpiece to  
2 laser powder fusion welding as set forth in Claim 1, wherein the laser head system further  
comprises:  
4 a tracing system determining topology of a workpiece.
5. A 3-D adaptive laser powder fusion welding system for subjecting a workpiece to  
2 laser powder fusion welding as set forth in Claim 1, wherein the tracing system further  
comprises:  
4 a laser rangefinder.

6. A 3-D adaptive laser powder fusion welding system for subjecting a workpiece to laser powder fusion welding as set forth in Claim 1, wherein the support apparatus further comprises:
- an x-axis prismatic element enabling linear travel along a first linear axis;
  - a y-axis prismatic element enabling linear travel along a second linear axis;
  - a roll revolute element enabling angular travel centered upon a roll axis;
  - a pitch revolute element enabling angular travel centered upon a pitch axis;
- and
- a yaw revolute element enabling angular travel centered upon a yaw axis;
- the x-axis, y-axis, roll revolute element, pitch revolute element, and yaw revolute elements coupled to one another.
7. A 3-D adaptive laser powder fusion welding system for subjecting a workpiece to laser powder fusion welding as set forth in Claim 1, further comprising:
- a filler delivery system providing filler material to the laser head system;
  - a laser supplying laser light to the laser head system; and
  - a controller system controlling operation of the filler delivery system, the laser, the laser head system, the linear displacement element, and the support apparatus.
8. A 3-D adaptive laser powder fusion welding system for subjecting a workpiece to laser powder fusion welding as set forth in Claim 7, wherein the laser further comprises a laser selected from the group consisting of:
- an Nd-YAG laser;
  - a CO<sub>2</sub> laser; and
  - an ytterbium fiber diode laser system.
9. A 3-D adaptive laser powder fusion welding system for subjecting a workpiece to laser powder fusion welding as set forth in Claim 7, wherein the controller system further comprises:
- a digital servo amplifier system coupled to the support apparatus and controlling operation of the five degrees of freedom.
10. A 3-D adaptive laser powder fusion welding system for subjecting a workpiece to

laser powder fusion welding as set forth in Claim 7, wherein the controller system further comprises:

a robot controller coupled to and controlling the laser head system, the linear displacement element, and the support apparatus.

11. A 3-D adaptive laser powder fusion welding system for subjecting a workpiece to laser powder fusion welding as set forth in Claim 7, wherein the controller system further comprises:

a computer programmably operating the controller system and enabling recording of data through the controller system.

12. A 3-D adaptive laser powder fusion welding system for subjecting a workpiece to laser powder fusion welding, the system comprising:

a laser head system including a laser welding head, a powder feed delivery system, and a tracing system determining topology of a workpiece;

a linear displacement element coupled to the laser head and enabling the laser head to be displaced linearly in a first dimension; and

a support apparatus capable of holding the workpiece adjacent the laser head in an adjustable and selectable manner, the support apparatus providing five degrees of freedom in second and third linear dimensions and first, second, and third rotational dimensions, the support apparatus including an x-axis prismatic element enabling linear travel along a first linear axis, a y-axis prismatic element enabling linear travel along a second linear axis, a roll revolute element enabling angular travel centered upon a roll axis, a pitch revolute element enabling angular travel centered upon a pitch axis, a yaw revolute element enabling angular travel centered upon a yaw axis, the x-axis, y-axis, roll revolute element, pitch revolute element, and yaw revolute elements coupled to one another;

a filler delivery system providing filler material to the laser head system;

a laser supplying laser light to the laser head system, the laser including a laser selected from the group consisting of:

an Nd-YAG laser;

a CO2 laser; and

an ytterbium fiber diode laser system; and

24                   a controller system controlling operation of the filler delivery system, the  
laser, the laser head system, the linear displacement element, and the support  
26                   apparatus, the controller system including:  
                    a digital servo amplifier system coupled to the support apparatus and  
28                   controlling operation of the five degrees of freedom;  
                    a robot controller coupled to and controlling the laser head system, the  
30                   linear displacement element, and the digital servo amplifier; and  
                    a computer programmably operating the robot controller and enabling  
32                   recording of data through the controller system; whereby  
the laser head may engage the workpiece about an exterior of the workpiece.

13.               A 3-D adaptive laser powder fusion welding system for subjecting a workpiece to  
2               laser powder fusion welding as set forth in Claim 12, wherein the tracing system further  
comprises:  
4               a laser rangefinder.